

WHAT IS CLAIMED IS:

1. A surface acoustic wave duplexer comprising:
an antenna terminal;
a transmission-side surface acoustic wave filter connected to the antenna terminal;
a receiving-side surface acoustic wave filter connected to the antenna terminal;
a package material on which the transmission-side surface acoustic wave filter and the receiving-side surface acoustic wave filter are mounted; and
a high-frequency wave element connected to the transmission-side surface acoustic wave filter and the receiving-side surface acoustic wave filter; wherein
the high-frequency wave element has two trap attenuation poles at frequencies higher than the frequencies of the transmission-side pass band.

2. A surface acoustic wave duplexer according to Claim 1, wherein the two trap attenuation poles are approximately equal to a twofold wave and a threefold wave of the transmission-side pass band.

3. A surface acoustic wave duplexer according to Claim 1, wherein the high-frequency wave element includes first and second

inductors and first, second, and third capacitance elements, and the two trap attenuation poles are formed by the first and the second inductors and the first, second, and third capacitance elements.

4. A surface acoustic wave duplexer according to Claim 3, wherein the first, second, and third capacitance elements have a delta-type connection in which two of the capacitance elements are connected to each of first, second, and third common terminals;

the first inductor is connected between the first common terminal and a ground potential; and

the second inductor is connected between the second and third common terminals.

5. A surface acoustic wave duplexer according to Claim 4, wherein a first trap attenuation pole is approximately equal to a twofold wave of a pass band of the transmission-side surface acoustic wave filter by an anti-resonance of the second inductor and a capacitance element connected in parallel to the second inductor; and

a second trap attenuation pole is approximately equal to a threefold wave of a pass band of the transmission-side surface acoustic wave filter by a resonance of a capacitance which has been obtained in a T-type connection equivalent to the delta-type connection of the first to the third capacitance elements and the

first inductor.

6. A surface acoustic wave duplexer comprising:

- an antenna terminal;
- a transmission-side surface acoustic wave filter connected to the antenna terminal;
- a receiving-side surface acoustic wave filter connected to the antenna terminal;
- a package material on which the transmission-side surface acoustic wave filter and the receiving-side surface acoustic wave filter are mounted;
- a high-frequency wave element includes at least one inductor and at least one capacitance element; and
- a common connecting point connected to one end of the transmission-side surface acoustic wave filter and connected to one end of the receiving-side surface acoustic wave filter;

wherein

- the high-frequency wave element is disposed only between the common connection point and the antenna terminal; and
- the inductor included in the high-frequency wave element is disposed in the package material.

7. A surface acoustic wave duplexer according to Claim 6, further comprising a phase-matching strip line disposed in the package material; wherein

the inductor included in the high-frequency wave element is

located on the same plane of the package material as the strip line.

8. A surface acoustic wave duplexer according to Claim 6, wherein the inductor is disposed so as to increase a magnetic flux over at least two layers in the package material.

9. A surface acoustic wave duplexer according to Claim 7, wherein the strip line and the inductor are disposed on at least two layers; and

the strip line and the inductor are disposed on the same at least two layers.

10. A surface acoustic wave duplexer comprising:

an antenna terminal;

a transmission-side surface acoustic wave filter which is connected to the antenna terminal and includes a piezoelectric substrate;

a receiving-side surface acoustic wave filter which is connected to the antenna terminal and includes a piezoelectric substrate;

a package material on which the transmission-side surface acoustic wave filter and the receiving-side surface acoustic wave filter are mounted; and

a high-frequency wave element which includes at least one inductor and at least one capacitance element; wherein

the capacitance element includes a comb-shaped electrode disposed on the piezoelectric substrate of the transmission-side and/or the receiving-side surface acoustic wave filter;

a direction along an electrode-finger pitch of the comb-shaped electrode is turned substantially 90 degrees with respect to a propagation direction of the surface acoustic wave in the surface acoustic wave filter on which the comb-shaped electrode is disposed; and

a ripple which occurs by the capacitance element is not located in the vicinity of a twofold wave and a threefold wave of a pass band of the transmission-side surface acoustic wave filter and a pass band of the receiving-side surface acoustic wave filter.

11. A surface acoustic wave duplexer according to Claim 10, wherein the piezoelectric substrate is a LiTaO₃ substrate, a pitch of an electrode finger of the comb-shaped electrode constituting the capacitance element falls in any one of the ranges of the following expressions (1) to (3):

$$5300/f_H \geq 2 \times P \quad \dots \text{Expression (1)}$$

$$6800/f_L \leq 2 \times P \leq 16500/f_H \quad \dots \text{Expression (2)}$$

$$18800/f_L \leq 2 \times P \quad \dots \text{Expression (3)}$$

where f_H is an upper limit frequency of the pass band of the receiving-side surface acoustic wave filter, f_L is a lower limit of the pass band of the filter of the transmission-side surface acoustic wave filter, and P is an electrode-finger pitch of the

comb-shaped electrode.

12. A surface acoustic wave duplexer according to Claim 11, wherein the pitch of the electrode finger of the comb-shaped electrode falls in any one of the ranges of the following expressions (4) to (12):

$$5500/f_H \geq 2 \times P \quad \dots \text{Expression (4)}$$

$$6800/f_L \leq 2 \times P \leq 16500/f_H \quad \dots \text{Expression (5)}$$

$$18800/f_L \leq 2 \times P \quad \dots \text{Expression (6)}$$

$$5500/(2 \times f_{TH}) \geq 2 \times P \quad \dots \text{Expression (7)}$$

$$6800/(2 \times f_{TL}) \leq 2 \times P \leq 16500/(2 \times f_{TH}) \dots \text{Expression (8)}$$

$$18800/(2 \times f_{TL}) \leq 2 \times P \quad \dots \text{Expression (9)}$$

$$5500/(3 \times f_{TH}) \geq 2 \times P \quad \dots \text{Expression (10)}$$

$$6800/(3 \times f_{TL}) \leq 2 \times P \leq 16500/(3 \times f_{TH}) \dots \text{Expression (11)}$$

$$18800/(3 \times f_{TL}) \leq 2 \times P \quad \dots \text{Expression (12)}$$

where f_{TL} is a lower limit frequency of the pass band of the transmission-side surface acoustic wave filter, f_{TH} is an upper limit frequency of the pass band of the transmission-side surface acoustic wave filter, and P is an electrode-finger pitch of the comb-shaped electrode.

13. A surface acoustic wave duplexer comprising:

an antenna terminal;

a transmission-side surface acoustic wave filter which is connected to the antenna terminal and includes a piezoelectric substrate;

a receiving-side surface acoustic wave filter which is connected to the antenna terminal and includes a piezoelectric substrate;

a package material on which the transmission-side surface acoustic wave filter and the receiving-side surface acoustic wave filter are mounted; and

a high-frequency wave element which has at least one inductor and at least one capacitance element; wherein

the capacitance element is defined by a laminated structure including a first electrode film, a second electrode film, and an insulation film located between the first and second electrode films disposed on a piezoelectric substrate of the transmission-side and/or the receiving-side surface acoustic wave filter.

14. A surface acoustic wave duplexer according to claim 10, wherein the transmission-side surface acoustic wave filter and the receiving-side surface acoustic wave filter have individual piezoelectric substrates, and a capacitance element of the high-frequency wave element is disposed on the piezoelectric substrate of the receiving-side surface acoustic wave filter.

15. A surface acoustic wave duplexer according to Claim 14, wherein the capacitance element of the high-frequency wave element is disposed in the vicinity of an end of an antenna-terminal side of the receiving-side surface acoustic wave filter.

16. A surface acoustic wave duplexer according to claim 10, wherein the transmission-side surface acoustic wave filter and the receiving-side surface acoustic wave filter are disposed on the same piezoelectric substrate, and a capacitance element of the high-frequency wave element is disposed in the vicinity of an end of an antenna-terminal side of the receiving-side surface acoustic wave filter.

17. A surface acoustic wave duplexer comprising:

an antenna terminal;

a transmission-side surface acoustic wave filter which is connected to the antenna terminal and includes a piezoelectric substrate;

a receiving-side surface acoustic wave filter which is connected to the antenna terminal and includes a piezoelectric substrate;

a package material on which the transmission-side surface acoustic wave filter and the receiving-side surface acoustic wave filter are mounted; and

a high-frequency wave element which has at least one inductor and at least one capacitance element; wherein

the inductor is disposed in the package material, and the capacitance element is disposed on the piezoelectric substrate of the transmission-side surface acoustic wave filter and/or the receiving-side surface acoustic wave filter.

18. A surface acoustic wave duplexer comprising:

- an antenna terminal;
- a transmission-side surface acoustic wave filter which is connected to the antenna terminal and includes a piezoelectric substrate;
- a receiving-side surface acoustic wave filter which is connected to the antenna terminal, and includes a piezoelectric substrate;
- a package material on which the transmission-side surface acoustic wave filter and the receiving-side surface acoustic wave filter are mounted;
- a high-frequency wave element which includes at least one inductor and at least one capacitance element; and
- a phase-adjusting strip line disposed in the package material; wherein

- the inductor is disposed on the same layers in the package material as that of the phase-adjusting strip line;
- the piezoelectric substrates of the transmission-side surface acoustic wave filter and the receiving-side surface acoustic wave filter are LiTaO_3 substrates;
- the capacitance element includes a comb-shaped electrode disposed on the piezoelectric substrate of one of the transmission-side surface acoustic wave filter and the receiving-side surface acoustic wave filter;
- a direction connecting electrode fingers of the comb-shaped electrode is substantially perpendicular to a propagation

direction of a surface acoustic wave in the surface acoustic wave filter; and

a pitch of an electrode finger of the comb-shaped electrode falls in any one of the ranges of the following expressions (13) to (15):

$$5300/f_H \geq 2 \times P \quad \dots \text{Expression (13)}$$

$$6800/f_L \leq 2 \times P \leq 16500/f_H \quad \dots \text{Expression (14)}$$

$$18800/f_L \leq 2 \times P \quad \dots \text{Expression (15)}$$

where f_H is an upper limit frequency of the pass band of the receiving-side surface acoustic wave filter, f_L is a lower limit of the pass band of the filter of the transmission-side surface acoustic wave filter, and P is an electrode-finger pitch of the comb-shaped electrode.

19. A surface acoustic wave duplexer comprising:

an antenna terminal;

a transmission-side surface acoustic wave filter connected to the antenna terminal;

a receiving-side surface acoustic wave filter connected to the antenna terminal;

a package material on which the transmission-side surface acoustic wave filter and the receiving-side surface acoustic wave filter are mounted;

at least one phase-matching element; and

a low-pass filter; wherein

the low-pass filter is connected between the antenna

terminal and the transmission-side surface acoustic wave filter and between the antenna terminal and the receiving-side surface acoustic wave filter; and

the low-pass filter has both of a low-pass filter function and an antenna-matching function.

20. A surface acoustic wave duplexer according to Claim 19, wherein the phase-matching element is disposed between a surface acoustic wave filter having a relatively high frequency and an antenna terminal, and an amount of phase delay in the phase-matching element is less than about 90 degrees at a center frequency of a surface acoustic wave filter having a relatively low frequency.

21. A surface acoustic wave duplexer according to Claim 20, wherein the amount of phase delay falls within a range of about 60 degrees to about 80 degrees.

22. A surface acoustic wave duplexer according to claim 19, wherein an impedance at an antenna terminal of the surface acoustic wave duplexer excluding the low-pass filter is inductive at least in a frequency range of about 50% or more of each pass band width of a transmission-side surface acoustic wave filter and a receiving-side surface acoustic wave filter, an impedance in a pass band of the low-pass filter is capacitive, and matching is obtained on a real axis when viewed from an antenna side.

antenna side.

23. A surface acoustic wave duplexer comprising:

- an antenna terminal;
- a transmission-side surface acoustic wave filter connected to the antenna terminal;
- a receiving-side surface acoustic wave filter connected to the antenna terminal;
- a package material on which the transmission-side surface acoustic wave filter and the receiving-side surface acoustic wave filter are mounted;
- a high-frequency wave element which has at least one inductor and at least one capacitance element;
- a common connection point connecting one end of the transmission-side surface acoustic wave filter and connecting one end of the receiving-side surface acoustic wave filter; wherein the high-frequency wave element is disposed only between the common connection point and the antenna terminal;
- the inductor is disposed in the package material;
- the capacitance element includes a comb-shaped electrode;
- a direction of an electrode-finger pitch of the comb-shaped electrode is turned substantially 90 degrees with respect to a propagation direction of the surface acoustic wave;
- a ripple which occurs due to the capacitance element is not located at a twofold wave and a threefold wave and in the vicinity of the twofold wave and the threefold wave of a pass

band of the transmission-side surface acoustic wave filter and a pass band of the receiving-side surface acoustic wave filter; and the high-frequency wave element has both of a low-pass filter function and an antenna-matching function.

24. A surface acoustic wave duplexer comprising:
an antenna terminal;
a transmission-side surface acoustic wave filter connected to the antenna terminal;
a receiving-side surface acoustic wave filter connected to the antenna terminal;
a package material on which the transmission-side surface acoustic wave filter and the receiving-side surface acoustic wave filter are mounted;
a phase-adjusting strip line disposed in the package material; and
a high-frequency wave element; wherein
the high-frequency wave element has two trap attenuation poles approximately equal to a twofold wave and a threefold wave of the transmission-side pass band;
the high-frequency wave element includes at least first and second inductors and first to third capacitance elements;
the first to the third capacitance elements are connected in a delta-type connection in which two of the capacitance elements are connected to each of first to third common terminals;
the first inductor is connected between the first common

terminal and ground potential;

the second inductor is connected between the second and third common terminals;

the second inductor is disposed on the same layers as that of the phase-adjusting strip line disposed in the package material; and

a terminal which is connected to the transmission-side signal terminal of the strip line and a terminal which is connected to the transmission-side signal terminal of the second inductor are short-circuited in the package material.